CLAIMS

We claim:

1. A microscale generator comprising:

a counterflow heat exchanger having a generally toroidal exterior surface and defining a central region with openings to a reactant gas channel and an exhaust gas channel and wherein the reactant channel and exhaust channel are coiled around each other and separated by a channel wall, wherein at least one portion of the channel wall comprises thermoelectric material and a plurality of thermally conducting fins;

a reactant gas inlet on the exterior surface of the heat exchanger in communication with the reactant gas channel;

an exhaust gas port on the exterior surface of the heat exchanger in communication with the exhaust gas channel; and

an electrical connection between the thermoelectric material and the exterior surface of the generator.

2. The generator of Claim 1 wherein the thermoelectric material comprises elements of thermoelectric material of n-type conductivity and elements of thermoelectric material of p-type conductivity.

3. The generator of Claim 2 wherein the fins are thermally and electrically conducting T-shaped fins in contact with the elements of thermoelectric material, the fins each having a base portion and a top portion substantially perpendicular to the base portion, the fins positioned such that each base portion is interposed between an element of n-type conductivity and an element of p-type conductivity, some of the fins extending into the reactant channel whereby their top portions are oriented substantially parallel to the direction in which gas flows in the reactant channel and some of the fins extending into the exhaust channel whereby their top portions are oriented substantially parallel to the direction in which gas flows in the exhaust channel, and wherein the top portion of each of the fins is at least three times longer than the base portion.

4. The generator of Claim 2 wherein the dimension of the elements of thermoelectric material of n-type conductivity in the direction along the channel wall is at least three times larger than the dimension of the elements of n-type conductivity in the

direction of the width of the channel wall and wherein a dimension of the elements of thermoelectric material of p-type conductivity in the direction along the channel wall is at least three times larger than a dimension of the elements of p-type conductivity in the direction of the width of the channel wall.

5. The generator of Claim 2 wherein the fins are thermally and electrically conducting L-shaped fins in contact with the elements of thermoelectric material, the fins each having a base portion and a top portion substantially perpendicular to the base portion, the fins positioned such that each base portion is interposed between an element of n-type conductivity and an element of p-type conductivity, some of the fins extending in the reactant channel from the base portion toward the direction from which reactant gas flows and some of the fins extending in the exhaust channel from the base portion toward the direction from which exhaust gas flows.

6. The generator of Claim 2 wherein the fins are thermally and electrically conducting asymmetric T-shaped fins in contact with the thermoelectric material, the fins each having a base portion and a top portion perpendicular to the base portion and having a longer side and shorter side, the fins positioned such that each base portion is interposed between an element of n-type conductivity and an element of p-type conductivity, some of the fins having their top portion in the reactant channel positioned such that the longer side is toward the direction from which reactant gas flows and some of the fins having their top portion in the exhaust channel such that the longer side is toward the direction from which exhaust gas flows.

7. The generator of Claim 2 wherein the channel walls are composed of an electrically conducting material.

8 The generator of Claim 7 wherein the electrically conducting material is platinum.

9. The generator of Claim 1 further comprising a partition wall juxtaposed between two partial toroidal portions of the heat exchanger.

10. The generator of Claim 9 wherein each of the partial toroidal portions is electrically independent and the partial toroidal portions are electrically coupled.

11. The generator of Claim 1 further comprising an igniter within the generator.

12. The generator of Claim 9 further comprising an igniter comprising resistive elements within the generator, wherein the resistive elements are in communication with an external power source through conductors positioned in the partition wall.

13. The generator of Claim 2 wherein the elements of thermoelectric material of n-type conductivity and the elements of thermoelectric material of p-type conductivity are electrodeposited.

14. The generator of Claim 2 wherein the elements of thermoelectric material of n-type conductivity and the elements of thermoelectric material of p-type conductivity further comprise particles of low thermal conductivity material.

15. The generator of Claim 1 further comprising bridging elements connecting channel walls.

16. The generator of Claim 1 wherein an outer diameter of the toroidal surface is between about 2 and about 15 millimeters.

17. A microscale combustor comprising:

a counterflow heat exchanger having a generally toroidal exterior surface, and defining a central region with openings to a reactant gas channel and an exhaust gas channel and wherein the reactant channel and exhaust channel are coiled around each other and separated by a channel wall, wherein an internal dimension of the central region is smaller than about 1 millimeter;

a reactant gas inlet on the exterior surface of the heat exchanger in communication with the reactant gas channel; and

an exhaust gas port on the exterior surface of the heat exchanger in communication with the exhaust gas channel.

18. The combustor of Claim 17 further comprising an igniter within the generator.

19. The combustor of Claim 17 wherein the width of the reactant channel and the width of the exhaust channel vary with radius from the axis of rotation.

20. A method of fabricating a microdevice by depositing layers of materials onto previously deposited layers by a method comprising the acts of:

providing a first mask comprising a patterned elastomer affixed to an electrode;

electrochemically depositing a sacrificial material using the first mask;

providing a second mask comprising a patterned elastomer affixed to a support;

electrochemically depositing a structural material using the second mask and an electrode separate from the second mask; and

blanket electrochemically depositing a thermoelectric material without use of a mask.

21. The method of Claim 20 further comprising, following the deposition of all layers, removing the sacrificial material.

22. The method of Claim 20 wherein the sacrificial material is copper, and the structural material comprises a metal selected from the group consisting of platinum and nickel.

23. A microdevice fabricated by the method of claim 20 wherein the microdevice comprises:

a counterflow heat exchanger having a generally toroidal exterior surface, and defining a central region with openings to a reactant gas channel and an exhaust gas channel and wherein the reactant channel and exhaust channel are coiled around each other and separated by a channel wall, wherein at least one portion of the channel wall comprises thermoelectric material;

a reactant gas inlet on the exterior surface of the heat exchanger in communication with the reactant gas channel;

an exhaust gas port on the exterior surface of the heat exchanger in communication with the exhaust gas channel; and

an electrical connection between the thermoelectric material and the exterior surface of the generator.

24. The generator of Claim 23 wherein the portion of the channel wall comprising thermoelectric material is oriented perpendicular to the planes of the layers.

25. The generator of Claim 22 wherein the elements of thermoelectric material are arranged so that each deposition layer contains elements of thermoelectric material only of n-type conductivity or only of p-type conductivity.

26. A method of fabricating a microdevice by depositing layers of materials on previously deposited layers according to a method comprising the acts of:

providing a first mask comprising a patterned elastomer affixed to an electrode;

electrochemically depositing a sacrificial material using the first mask;

providing a second mask comprising a patterned elastomer affixed to a support;

electrochemically depositing a thermoelectric material using the second mask and an electrode separate from the mask; and

blanket electrochemically depositing a structural material without use of a mask.

27. A mask for selectively electrodepositing material, the mask comprising a patterned elastomeric material affixed to a non-electrode support, wherein the support is perforated.

28. The method of Claim 20 further comprising the acts of:

blanket electrochemically depositing a barrier material without use of a mask before blanket electrochemically depositing a thermoelectric material without use of a mask; and

following the deposition of all layers, removing sacrificial material and portions of barrier material exposed to open space in the generator.

29. The generator of Claim 28 wherein the sacrificial material is copper, the structural material is platinum, the barrier material is gold, and the thermoelectric material comprises bismuth and tellurium.